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LIQUID CRYSTAL DISPLAY DEVICE

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ABSTRACT

PURPOSE: To obtain a liquid crystal display device in which the non-uniformity or lowering of a contrast ratio can be prevented from occuring even when it is displayed for a long time and satisfactory display characteristic with a wide visual angle and high contrast can be obtained.

CONSTITUTION: A lateral electric field electrode 15 is arranged adjacently to one side 14a of an electrode 14 to form picture element electrodes 14 arranged in matrix shape in two areas A, B with different tilting directions of a liquid crystal molecule, and reverse tilt is generated by a lateral electric field at a part of the area for normal tilt decided by the orientation of orientation film 19, 23. The boundary of different tilt areas can be decided by an auxiliary capacitor (Cs) line 16 which bisects the picture element electrode.

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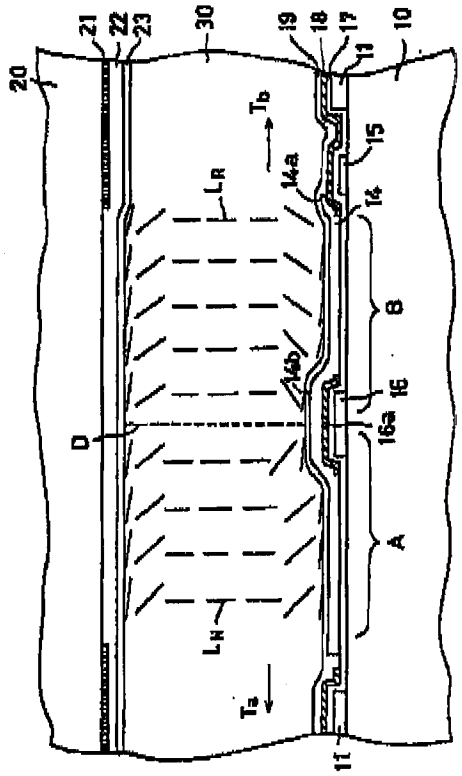
(54)【発明の名称】液晶表示装置

(57)【要約】

【構成】　マトリクス状に配置された画素電極１４のそれぞれを液晶分子のチルト方向の異なる２領域Ａ、Ｂに形成するために、電極１４の１辺１４ａに隣接して横電界発生電極１５を配置し、配向膜１９、２３の配向によってきまるノーマルチルトに対して、その領域の一部に横電界によってリバースチルトを生じさせる。異なるチルト領域の境界は画素電極を２分する補助容量（Cs)線１６によって画定する。

【効果】　長時間表示してもコントラスト比の不均一や低下が発生せず、視野角の広い良好な表示特性で高コントラストの液晶表示装置を得ることができる。



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【特許請求の範囲】

【請求項1】　行方向および列方向にそれぞれ配列形成される複数本の走査線および複数本の信号線と、マトリクス状に配置され前記走査線および信号線により制御される能動素子およびこれに接続される画素電極が形成され、前記画素電極を覆うように形成された配向膜を具備したアレイ基板と、前記画素電極と対向して置かれる共通電極と前記共通電極上に形成された配向膜を具備した対向基板を備え、前記アレイ基板と対向基板の間隙に配設され前記配向膜により液晶分子が所定の角度および方向にプレチルトされる液晶層とを具備した液晶表示装置において、前記液晶分子のプレチルト角発生方向と反対方向の画素電極外周に隣接して横電界発生電極を設けたことを特徴とする液晶表示装置。

【発明の詳細な説明】

【0001】

【産業上の利用分野】この発明は液晶表示装置に係り、特にTN型の液晶表示装置に関する。

【0002】

【従来の技術】近年、薄型軽量、低消費電力という大きな利点をもつ液晶表示装置は、日本語ワードプロセッサ、デスクトップパーソナルコンピュータ等のパーソナルOA機器の表示装置や、テレビ等の映像表示装置として積極的に用いられている。特に、アクティブマトリクス型の液晶表示装置は、高解像度の表示が実現できることから、開発が盛んに行われている。

【0003】従来のアクティブマトリクス型の液晶表示装置のアレイ基板は、絶縁性基板の一主面上に行方向に複数本の走査線および列方向に複数本の信号線が配列形成され、前記走査線および信号線の交差位置に薄膜トランジスタ（以下TFTと略す）およびこれに接続される画素電極からなる一画素が形成され、その上に配向膜が形成されている。一方、上部の対向基板は絶縁性基板の一主面上に共通電極が形成され、その上に配向膜が形成されている。アレイ基板と対向基板を前述の電極が形成されている主面を対峙させ、間隙に液晶剤を挟持させている。通常、アレイ基板側と対向基板側では90度ずれた方向に配向膜を配向処理してあるため、液晶分子が厚さ方向に90度捩じれて並ぶTN型液晶が使われている。

【0004】TN型の液晶表示装置は、見る方向によってコントラスト比や表示色が変化するという視野角依存性がある。従来の液晶表示装置の視野角依存性を測定したデータの一例を図6に示す。基板表面の正対位置を基準に、上下方向に観察方向を変えたときの特性で視野角θすなわち視点の角度θに対してコントラスト比は対称にならない。一般に視点の角度θによりコントラスト比が大きく変化するが、角度θがマイナスに振れると表示色の反転が起こるので、観察位置に制限がある。

【0005】このような視野角依存性を改善するため、

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種々の技術が提案されているが、そのほとんどが、配向処理に関するものである。例えば、特開昭63-106624号公報、特開昭64-88520号公報、特開平1-245223号公報では各画素を複数の領域に分割し、それぞれの領域の配向方向が異なるように配向処理をすることによって、視野角依存性を改善している。このような配向処理の手法について、例えば、特開昭60-211421号公報、特開昭60-211422号公報、特開昭60-211423号公報、特開昭60-211424号公報に記載されているが、プロセスが非常に複雑になり、生産性が低いという問題点がある。また、TN液晶用の配向膜として一般に普及しているポリイミドは所定のパターンにエッチングするのが難しく、前述のような配向処理が異なる領域を作製することができない。従って、画素を分割して配向方向が異なる領域を得るには、保持率やプレチルト角等、液晶表示装置の配向膜としての信頼性が高いポリイミドを使用し難いため、配向膜としての特性とパターニング容易性を兼ね備えた新しい配向膜が必要となるが、これ以上に適した部材はまだ現れていないのが現状である。

【0006】ところで、画素電極の周囲にはバスラインが形成されているため、バスラインからの横方向電界によりプレチルトの方向とは異なる方向に液晶分子が立ち上がるチルトリバースという現象が生じ易い。このチルトリバースは正常なチルト領域との境界にディスクリネーションラインが発生し、バスラインの電圧によって変動するので、画質の不良として通常ブラックマトリクスで覆い隠されている。また、チルトリバース領域の発生を防止するための提案が多数なされているが、完全に解消するに至っていない。

【0007】

【発明が解決しようとする課題】上述のように従来の液晶表示装置においては、視野角依存性があり、良好な画像が得られないという問題点があった。

【0008】本発明は、このような従来の問題点に鑑みてなされたものであり、広範囲の視野角において良好な画質が得られる液晶表示装置を提供することを目的とする。

【0009】

【課題を解決するための手段】本発明は、行方向および列方向にそれぞれ配列形成される複数本の走査線および複数本の信号線と、マトリクス状に配置され前記走査線および信号線により制御される能動素子およびこれに接続される画素電極が形成され、前記画素電極を覆うように形成された配向膜を具備したアレイ基板と、前記画素電極と対向して置かれる共通電極と前記共通電極上に形成された配向膜を具備した対向基板を備え、前記アレイ基板と対向基板の間隙に配設され前記配向膜により液晶分子が所定の角度および方向にプレチルトされる液晶層とを具備した液晶表示装置において、前記液晶分子のプレチルト角発生方向と反対方向の画素電極外周に隣接し

て横電界発生電極を設けたことを特徴とする液晶表示装置にある。

【0010】本発明の横電界発生電極は、画素電極との間に横方向電界を発生させ、液晶分子のプレチルトの方向とは異なる方向にチルト角を与えるためのもので、異なる方向にチルト角を付与される領域をリバースチルト領域とする。加える電極は必要とされるリバースチルト領域の大きさにより適宜決定すればよい。

【0011】本発明のプレチルト角発生方向は配向膜により液晶分子に与えられるチルト角の方向であり、画素電極と共通電極により均一な電界が与えられた場合に、液晶分子が立ち上がる方向である。

【0012】

【作用】本発明では、横電界発生電極と画素電極の間に横電界を加えることにより、リバースチルト領域を発生させる。リバースチルト領域とノーマルチルト領域が一つの画素内に形成されるため、ラビング方向が異なる領域を一画素内に設けた場合と同様の効果が生じる。すなわち、リバースチルト領域が視野角依存性を低減し、視野角が一画素全体として平均化され、画面全体では視野角依存性が低減され良好な画像を得ることができるようになる。

【0013】

【実施例】以下本発明の実施例について述べる。

【0014】（実施例1）図1および図2は本発明の実施例を示し、ガラスでなる下部の基板10には、複数の平行な走査線11と信号線12が交差して形成され、交差部には能動スイッチング素子としてTFT13が形成されている。平行するそれぞれ2本の走査線11と信号線12で区画する領域には画素電極14が形成されてマトリックス状に配置されTFT13に接続されている。画素電極14の矢印Rで示すラビング方向の進入側の外周辺14aと走査線11の間には、走査線11に平行にストライプ状の横電界発生電極15が形成されている。この横電界発生電極15は任意の電圧が印加可能に形成される。さらにこの横電界発生電極15に平行にしかも画素電極14の下地でこの画素電極を2分する位置に補助容量線（Cs 線）16を配置する。横電界発生電極15の上に、走査線11と信号線12の間の層間絶縁膜となる酸化けい素層（SiOx）層17，窒化けい素層（SiNx）層18が形成され、この上に更に配向膜19が形成される。

【0015】一方、上部のガラス基板20にはブラックマトリクス21および共通電極22が形成され、更に配向膜23が形成される。ブラックマトリクス21は走査線、信号線からなるバスラインと、画素電極14の端部とを覆うように配置される。これら2枚の基板の間隙には液晶層30が挟持される。

【0016】動作時は、共通電極22を基準にして画素電極14に例えば3V、横電界発生電極15に例えば15Vが印加されると、図のように液晶分子LR が横電界発生電極15と画素電極14の間の横電界によりチルト角を制御させて、画素電極14のラビング進入方向側の辺14aの領域は矢印Tb 方向にチルト角が生じリバースチルト領域Bとなる。

【0017】一方、ラビング進行方向側は横電界の影響がなく液晶分子LN は配向膜の配向方向にしたがいチルト角発生方向はTb であり、ノーマルチルト領域Aのまま保持される。このため2つの領域の境界にはディスクリネーションラインDやウォールができる。ブラックマトリクス層16aを有するCs 線16はこのディスクリネーションラインDを隠すようにが配置される。

【0018】このようにリバースチルト領域Bとノーマルチルト領域Aが一つの画素内に形成されるため、視野角依存性が低減され、良好な画像を得ることができるようになる。

【0019】次に本実施例の製造方法について説明する。

【0020】まず下部のアレイ基板10は、ガラス等の絶縁透明材料からなる基板上に、スパッタリング法でMoTa合金等の金属膜を250nm成膜後、パターニング、ケミカリドライエッチング法CDEによりエッチングし、所定の形状の10μm幅のCs 線16および8μm幅の走査線11、ゲート電極13G、8μm幅の横電界発生電極15を形成する。次に、SiOx 層17をプラズマCVD法により350nm、a－Si膜（図示せず）、SiNx 層18をプラズマCVD法でそれぞれ50nm，200nm形成し、SiNx 層を弗酸系のエッチング液がエッチングし、TFTのチャネル保護層（図示せず）を形成する。オーミックコンタクトとなるようにするためn⁺ a－Si膜（図示せず）をプラズマCVD法により50nm成膜する。CDEによりn⁺ a－Si膜、a－Si膜、SiNx 層18をエッチングし、所定の形状にする。

【0021】スパッタリング法でCr，Alをそれぞれ50nm，500nm積層して成膜し、パターニングとして硝酸燐酸酢酸混合溶液および硝酸セリウムアンモニウム溶液で、Cr，Alをそれぞれエッチングし、8μm幅の信号線12、ソース電極13S、ドレイン電極13Dを形成する。ソース電極13Sとドレイン電極13Dの間に露出したn⁺ a－Si膜をソース電極13S、ドレイン電極13Dをマスクにして、CDEでエッチング、除去する。更にITO（インジウム錫酸化物）などの透明導電膜を100nmスパッタ法で形成し、パターニングし、王水系エッチング液でエッチングし65μm×65μmの短形状の画素電極5を形成する。パッシベーション膜（図示せず）としてSiNx を200nm成膜する。更に、配向膜用にポリイミド薄膜を100nm形成した後、この配向膜19の表面をラビング処理する。

【0022】この結果、画素電極14の一辺14aの周縁が横電界発生電極15に対して、絶縁層17、18を隔ててその上面に重なるように配置される。また、画素電極を2分する中央にCs 線16の厚みによる突状リッジ16bが形成される。このリッジ16bはリバースチルト領域Bとノーマルチルト領域Aの境界を形成しやすくするもので、横電界を発生したときに、このリッジと横電界発生電極間の画素電極領域を配向膜19のチルト方向（領域A）とは異なるリバースチルト状態にする。

【0023】一方、上部の基板20は、ガラス等の絶縁透明材料からなり、その上にブラックマトリクス21となるCr等の金属膜を300nmスパッタ法で形成し、フォトリソグラフィで格子状にパターニングする。透明導電膜を100nmスパッタ法で形成し、共通電極22とする。更に、ポリイミド薄膜を100nm形成した後、配向膜23の表面をラビング処理を行う。

【0024】この後、アレイ基板10の配向膜19の周辺に沿って接着剤としてエポキシ系接着剤を注入口（図示せず）を除いて印刷した。次にアレイ基板の表面に間隙材（図示せず）として粒径5μmの微細球（積水ファインケミカル社製のミクロパール（商品名））を散布した。次に配向膜19、23が対向し、またそれぞれのラビング方向が90度となるよう上下の基板を配置し、加熱して接着剤を硬化させ両基板10、20を貼り合わせた。

【0025】次に通常の方法により注入口より液晶材として、ZLI-1565（E．メルク社製）にS811（E．メルク社製）を0．1wt%添加したものを注入し5μm厚の液晶層30とし、この後注入口を紫外線硬化樹脂で封止した。

【0026】さらにこの後上下の基板に偏光板を貼り合わせ、アクティブマトリクス型液晶表示装置を作製した。

【0027】このようにして作製した本発明による液晶表示装置の視野角依存性を調べたところ、図3に示すような良好な結果が得られた。すなわち図3は基板垂直方向を基準にして観察方向に傾いた角度を視野角θとしたときの、コントラスト比を示すもので、上方、下方ともにほぼ対称的なコントラスト比が得られることが分かる。

【0028】（実施例2）図4は本実施例の液晶表示装置を示し、図2と同一符号は同様な部分を示す。図に示すように下部のアレイ基板10には、走査線11と画素電極14の間に横電界発生電極15が形成される。横電界発生電極15は横電界発生電極15と信号線12の間の層間絶縁膜となるSiOx 層27，SiNx 層28上に形成され画素電極14の周縁14aよりも上面に配置される。

【0029】SiOx 層27，SiNx 層28および横電界発生電極15は次のようなプロセスで形成される。SiOx 層27はプラズマCVD法により350nm、SiNx 層28はプラズマCVD法でそれぞれ200nm形成し、CDEによりSiOx 層27、SiNx 層28をエッチングし、所定の形状にする。さらに、スパッタリング法でCr，Alをそれぞれ50nm，500nm積層して成膜し、パターニングとして硝酸燐酸酢酸混合溶液および硝酸セリウムアンモニウム溶液で、Cr，Alをそれぞれエッチングし横電界発生電極15を形成する。

【0030】このように、横電界発生電極15が画素電極の辺部分14aよりも上面に位置するので、画素電極14の領域と対向基板の電極22との間に形成される電界に、基板に平行な横電界成分を付与しやすく、小電界でリバースチルト領域Bを形成できる。

【0031】（実施例3）以下第3の実施例について述べる。

【0032】図5は本実施例の液晶表示装置の実施例で図2と同一符号は同様な部分を示す。

【0033】図に示すようにアレイ基板10には、走査線11で挟むように画素電極14が形成され、走査線11と画素電極14の間には横電界発生電極15が形成されている。一方、対向基板20にはブラックマトリクス21と共通電極22が形成されているが、共通電極22の横電界発生電極15に対応する位置は切り欠き部22aとなっている。このように横電界発生電極15上の共通電極を取り除くことにより、横電界を強く発生させることができる。

【0034】更に、本実施例では共通電極22のCs 線16に対応する位置は切り欠き部22bとなっている。このようにCs 線16上の共通電極を取り除くことにより、安定にリバースチルト領域Bを形成することができる。

【0035】本発明で用いられる配向膜はどの様なものであってもよいが、プレチルト角が低いものが好ましく、1度以下が望ましい。プレチルト角が1度以下の場合、横電界発生電極に加える電圧が低くてもチルトリバース領域を広くすることが可能である。

【0036】プロジェクター用の液晶表示装置等、一画素が小さい場合には要求されるチルトリバース領域の大きさが小さくなるため、横電界発生電極に加える電圧が低くても視野角を良好にすることができる。

【0037】また、本発明の横電界発生電極は画素電極のラビング進入方向近傍に形成されるものであり、形状、材質などはチルトリバース領域が所定の範囲となるよう適宜決定すれば良い。

【0038】本発明のチルトリバース領域の範囲は視野角をどの様に設計するかにより、決定されるものであり、ノーマルチルト領域とチルトリバース領域の比は1対1に限定されるものではない。

【0039】

【発明の効果】本発明によれば、長時間表示してもコントラスト比の不均一や低下が発生せず、視野角の広い良好な表示特性で高コントラストの液晶表示装置を得ることができる。

【図面の簡単な説明】

【図1】本発明による一実施例の一基板の概略平面図、

【図2】図1をI－I線に沿って切断して示す概略断面図、

【図3】本発明による一実施例の視野角θとコントラスト比の特性を表す図、

【図4】本発明による他の実施例の一基板の概略断面図、

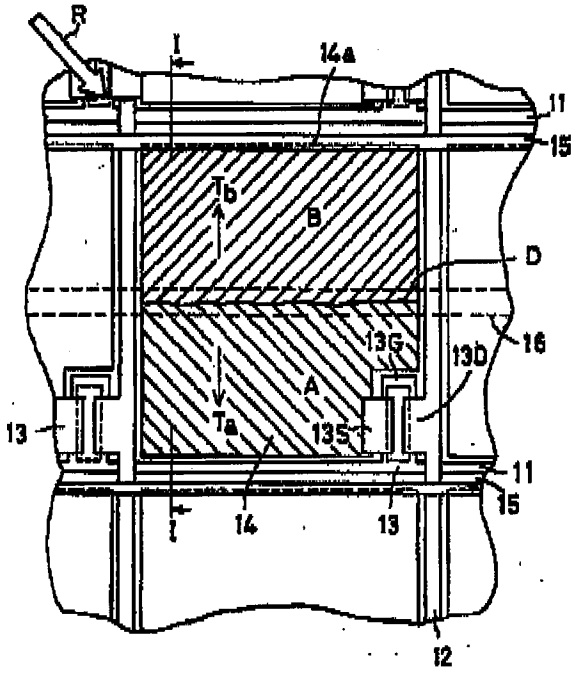
【図5】本発明による他の実施例の一基板の概略断面図、

【図6】従来の液晶表示装置の視野角θとコントラスト比の特性を表す図。

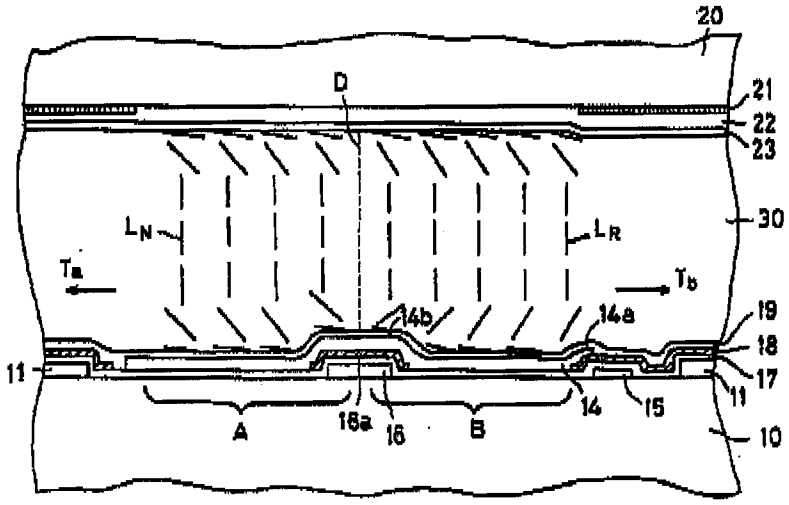
【符号の説明】

10…アレイ基板	11…走査線
12…信号線	13…TFT
14…画素電極	15…横電界発生電極
16…補助容量線（Cs 線）	
20…対向基板	30…液晶層
A…ノーマルチルト領域	B…リバースチルト領域
D…ディスクリネーションライン	

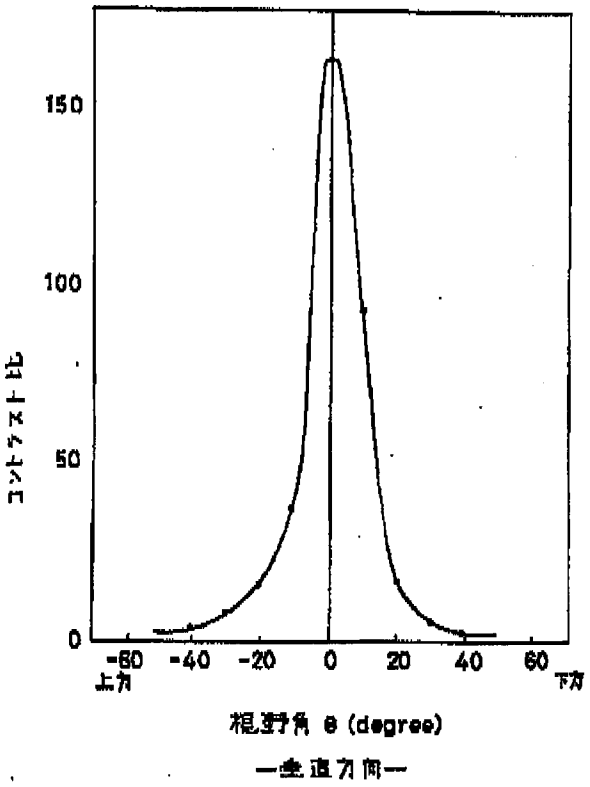
【図1】



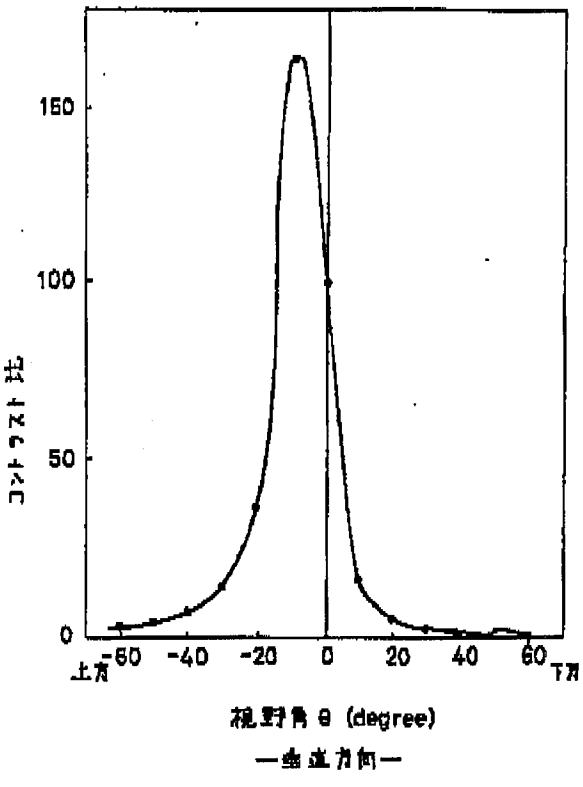
【図2】



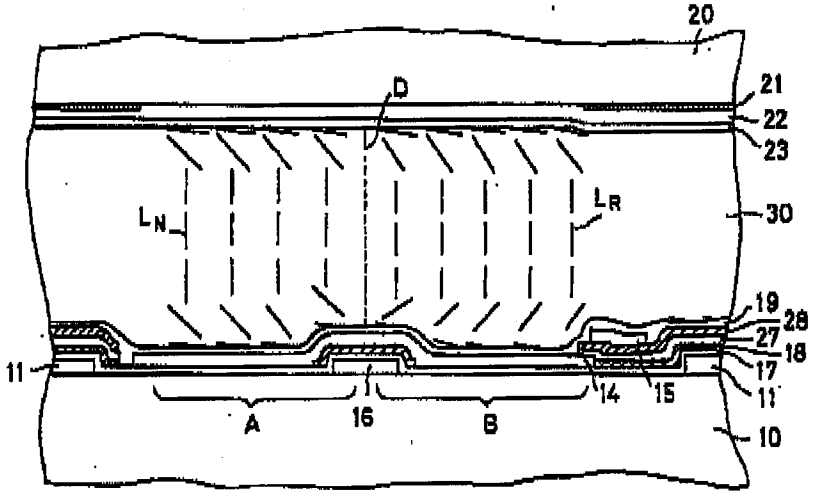
【図3】


150
100
50
0
コントラスト比
-60
-40
-20
0
20
40
60
上方
下方
視野角 θ (degree)
—垂直方向—

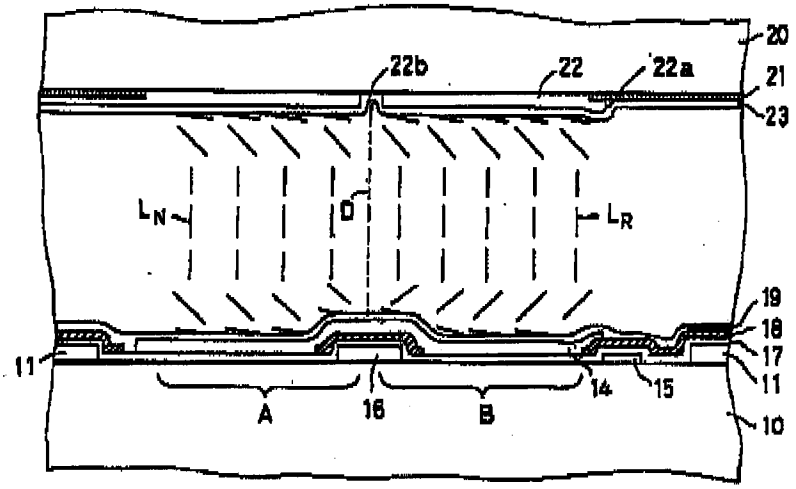
【図6】


150
100
50
0
コントラスト比
-60
-40
-20
0
20
40
60
上方
下方
視野角 θ (degree)
—垂直方向—

【図4】


20
D
21
22
23
L_N
L_R
30
19
28
27
18
17
11
11
14
15
A
16
B
10

【図5】



【公報種別】特許法第１７条の２の規定による補正の掲載
【部門区分】第６部門第２区分
【発行日】平成１３年１月１２日（２００１．１．１２）

【公開番号】特開平６－１１８４２６
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【年通号数】公開特許公報６－１１８５
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【国際特許分類第７版】
G02F　1/1343
【ＦＩ】
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【手続補正書】
【提出日】平成１１年１０月６日（１９９９．１０．６）
【手続補正１】
【補正対象書類名】明細書
【補正対象項目名】特許請求の範囲
【補正方法】変更
【補正内容】
【特許請求の範囲】
【請求項１】　行方向および列方向にそれぞれ配列形成される複数本の走査線および複数本の信号線と、マトリクス状に配置され前記走査線および信号線により制御される能動素子およびこれに接続される画素電極が形成され、前記画素電極を覆うように形成された配向膜を具備したアレイ基板と、前記画素電極と対向して置かれる共通電極と前記共通電極上に形成された配向膜を具備した対向基板を備え、前記アレイ基板と対向基板の間隙に配設され前記配向膜により液晶分子が所定の角度および方向にプレチルトされる液晶層とを具備した液晶表示装置において、各画素電極内の一部領域に対応する液晶分子の立ち上り方向もしくは立ち下がり方向を前記一部領域以外の領域と異なるように制御する横電界発生電極を有することを特徴とする液晶表示装置。
【手続補正２】
【補正対象書類名】明細書
【補正対象項目名】０００１
【補正方法】変更
【補正内容】
【０００１】
【産業上の利用分野】この発明は液晶表示装置に関する。
【手続補正３】
【補正対象書類名】明細書
【補正対象項目名】００１１
【補正方法】削除

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(54) [Title of the Invention]
Liquid crystal display device

(57) [Abstract]
[Structure]
A transverse electric field generating electrode 15 is disposed adjacent to a side 14a of a pixel electrode 14 in order to form regions A and B within each pixel electrode 14 arranged in a matrix. The regions A and B are regions in which a tilt direction of liquid crystal molecules is different from the other. Normal tilt is formed by alignment of alignment films 19 and 23. On the other hand, reverse tilt is generated in part of the

normal tilt region by a transverse electric field. An interface between the different tilt regions is fixed by an auxiliary capacitor (Cs) line 16 dividing the pixel electrode into two portions.

[Effect]

A liquid crystal display device having satisfactory display characteristics of a wide viewing angle and a high contrast, in which the contrast ratio is neither varied nor lowered regardless of the long time display, can be obtained.

[Scope of Claim]

[Claim 1]

A liquid crystal display device comprising:

an array substrate having a plurality of scanning lines and a plurality of signal lines each arranged in a column and a row, an active element arranged in a matrix and controlled by the scanning line and the signal line, a pixel electrode connected to the active element, and an alignment film formed to cover the pixel electrode;

an opposite substrate having a common electrode disposed to face to the pixel electrode and an alignment film formed over the common electrode; and

a liquid crystal layer disposed between the array substrate and the opposite substrate, and in which liquid crystal molecules are pretilted in a predetermined angle and direction by the alignment films,

wherein a transverse electric field generating electrode is formed adjacent to an outer periphery of the pixel electrode in an opposite direction to the direction in which the pretilt angle of the liquid crystal molecules is generated.

[Detailed Description of the Invention]

[0001]

[Industrial Field of the Invention]

This invention relates to a liquid crystal display device, especially to a TN type liquid crystal display device.

[0002]

[Prior Art]

In recent years, a liquid crystal display device, which has great advantages of thinness, lightness, and low power consumption, has been actively used as display device of personal OA equipment such as Japanese word processor or desktop personal computer, or as graphic display device such as television. In particular, an active matrix liquid crystal display device has been developed actively because high-resolution display can be realized.

[0003]

In an array substrate of a conventional active matrix liquid crystal display device, a

plurality of scanning lines and a plurality of signal lines are arranged in a row and a column respectively over the major surface of an insulating substrate. In addition, a pixel consisting of a thin film transistor (hereinafter abbreviated as TFT) formed in the intersection of the scanning line and the signal line and a pixel electrode connected to the TFT is formed and further an alignment film is formed thereover. On the other hand, in an opposite substrate, a common electrode is formed over the major surface of an insulating substrate, and further an alignment film is formed thereover. The major surfaces of the array substrate and the opposite substrate in which the electrodes are formed are disposed to face to each other, and a liquid crystal agent is interposed therebetween. In general, an aligning process is performed to the alignment films on the array substrate side and the opposite substrate side so that the alignment directions are different by 90°; therefore, a TN type liquid crystal in which liquid crystal molecules align to be twisted by 90° in the thickness direction is used.

[0004]

The TN type liquid crystal display device has dependence on a viewing angle, that is, a contrast ratio and display color are changed depending on a viewing direction. An example of data obtained by measuring the viewing angle dependence of a conventional liquid crystal display device is shown in FIG. 6. There is a characteristic that the contrast ratio is not symmetrical to a viewing angle θ, that is an angle of a view point θ, when a viewing direction is changed up and down with respect to the correct position of the surface of the substrate. The contrast ratio is generally changed a lot depending on the angle of the view point θ, but the display color is inverted if the angle θ becomes minus; thus, there are limitations on the observed position.

[0005]

Many kinds of techniques are proposed in order to improve the viewing angle dependence, most of which relate to an aligning process. For example, Japanese Patent Laid-Open Publication No. S63-106624, Japanese Patent Laid-Open Publication No. S64-88520, and Japanese Patent Laid-Open Publication No. H1-245223 disclose the following technique for the purpose of improving the viewing angle dependence: each pixel is divided into a plurality of regions, and an aligning process is performed so that an aligned direction of each region is different from the others. Although this kind of alignment method is described in, for example, Japanese Patent Laid-Open Publication No. S60-211421, Japanese Patent Laid-Open Publication No. S60-211422, Japanese Patent Laid-Open Publication No. S60-211423, and Japanese Patent Laid-Open Publication No. S60-211424, there are problems of the extremely complicated process and low productivity. In addition, polyimide that is generally used as an alignment film for the TN liquid crystal is

so difficult to be etched to have a predetermined pattern that the above described regions in which the different aligning processes are performed can not be formed. Accordingly, a new alignment film that has properties as an alignment film and that is easy to be patterned is required for obtaining the regions in which aligned directions are different from each other by dividing a pixel because it is difficult to use polyimide showing high reliability in the retention rate, the pretilt angle, or the like as an alignment film of a liquid crystal display device. However, there is no member more suitable than polyimide now.

[0006]

Meanwhile, since a bus line is formed around a pixel electrode, a tilt reverse phenomenon, in which liquid crystal molecules stand up in the different direction from the pretilt direction due to a transverse electric field from the bus line, happens easily. A disclination line is generated in an interface with a normal tilt region, and this line is transferred depending on the voltage of the bus line; thus, this tilt reverse as the deterioration of an image quality is usually covered by a black matrix. In addition, many suggestions are made to prevent the generation of the tilt reverse region; however, problems are not completely solved yet.

[0007]

[Problem to be Solved by the Invention]

As described above, a conventional liquid crystal display device has problems that there is a viewing angle dependence and fine images can not be obtained.

[0008]

The present invention has been accomplished in view of the above conventional problems, and it is an object to provide a liquid crystal display device in which fine images can be obtained in a large range of a viewing angle.

[0009]

[Means for Solving the Problem]

The present invention is a liquid crystal display device comprising an array substrate having a plurality of scanning lines and a plurality of signal lines each arranged in a column and a row, an active element arranged in a matrix and controlled by the scanning line and the signal line, a pixel electrode connected to the active element, and an alignment film formed to cover the pixel electrode; an opposite substrate having a common electrode disposed to face to the pixel electrode and an alignment film formed over the common electrode; and a liquid crystal layer disposed between the array substrate and the opposite substrate, and in which liquid crystal molecules are pretilted in a predetermined angle and direction by the alignment films, wherein a transverse electric field generating electrode is formed adjacent to an outer periphery of the pixel electrode in an opposite direction to the

direction in which the pretilt angle of the liquid crystal molecules is generated.

[0010]

A transverse electric field generating electrode according to the present invention generates a transverse electric field with a pixel electrode and gives a tilt angle in the different direction from a pretilt direction of liquid crystal molecules. Further, a region in which a tilt angle is given in the different direction is defined as a reverse tilt region. The voltage to be applied may be set appropriately depending on the required size of the reverse tilt region.

[0011]

A direction in which a pretilt angle is generated according to the invention is one of a tilt angle given by an alignment film to liquid crystal molecules, and one in which liquid crystal molecules stand up when a uniform electric field is applied by a pixel electrode and a common electrode.

[0012]

[Operation]

In the present invention, a reverse tilt region is generated by applying a transverse electric field between a transverse electric field generating electrode and a pixel electrode. Since the reverse tilt region and a normal tilt region are formed in one pixel, it has the same effect as the case where regions having different rubbing directions are formed in one pixel. That is, the reverse tilt region decreases the viewing angle dependence and a viewing angle is uniformed at a level of an entire one pixel; thus, the viewing angle dependence is decreased and fine images can be obtained at a level of an entire screen.

[0013]

[Embodiment]

Hereinafter, embodiments of the present invention are described.

[0014]

(Embodiment 1)

Embodiment of the present invention is shown with reference to FIG. 1 and FIG. 2. A plurality of parallel scanning lines 11 and signal lines 12 are formed so as to be intersected, and a TFT 13 is formed as an active switching element at the intersection over a lower substrate 10 made of glass. A pixel electrode 14 is formed in a region comparted by the two scanning lines 11 and signal lines 12 each in parallel; further, the pixel electrode 14 is arranged in a matrix and is connected to the TFT 13. A transverse electric field generating electrode 15 parallel to the scanning line 11 is formed in a stripe pattern between an outer periphery 14a of the pixel electrode 14 on an approaching side of the rubbing direction denoted by an arrow R and the scanning line 11. The transverse electric field

generating electrode 15 is formed so that arbitrary voltage can be applied. Furthermore, an auxiliary capacitor line (Cs line) 16 is disposed parallel to this transverse electric field generating electrode 15 and also disposed in a position dividing this pixel electrode 14 in half by being the base of the pixel electrode 14. A silicon oxide (SiO_x) layer 17 and a silicon nitride (SiN_x) layer 18 becoming interlayer insulating films between the scanning line 11 and the signal line 12 are formed over the transverse electric field generating electrode 15; further, an alignment film 19 is formed thereover.

[0015]

On the other hand, a black matrix 21 and a common electrode 22 are formed over an upper glass substrate 20, and an alignment film 23 is also formed. The black matrix 21 is disposed to cover a bus line formed of the scanning line and the signal line and to cover an edge portion of the pixel electrode 14. A liquid crystal layer 30 is interposed between these two substrates.

[0016]

If, for example, voltages of 3V and 1V is applied to the pixel electrode 14 and the transverse electric field generating electrode 15 respectively on the basis of the common electrode 22 during operation, the tilt angle is controlled by liquid crystal molecules L_R due to the transverse electric field between the transverse electric field generating electrode 15 and the pixel electrode 14 as shown in the figure. Thus, a tilt angle is generated in a direction denoted by an arrow Tb in a region of the periphery 14a of the pixel electrode 14 on the approaching side of the rubbing direction, and the region becomes a reverse tilt region B.

[0017]

On the other hand, a side of the rubbing proceeding direction is not under the influence of the transverse electric field, and a tilt angle generating direction of liquid crystal molecules L_N is T_b depending on the alignment direction of the alignment films; thus, the region is maintained to be a normal tilt region A. Accordingly, a disclination line D or a wall is formed in an interface between the two regions. The C_S line 16 including a black matrix layer 16a is disposed to cover this disclination line D.

[0018]

As described above, the reverse tilt region B and the normal tilt region A are formed in one pixel. Thus, the viewing angle dependence is decreased and fine images can be obtained.

[0019]

Next, a manufacturing method of this embodiment is explained.

[0020]

The lower array substrate 10 is formed as follows. First, a metal film such as an MoTa alloy is formed to have a film thickness of 250 nm by a sputtering method over a substrate formed of an insulating transparent material such as glass, and then it is patterned and etched by a chemical dry etching method (CDE) to form the Cs line 16 of 10 μm width and the scanning line 11 of 8 μm width, a gate electrode 13G, and the transverse electric field generating electrode 15 of 8 μm width each having a predetermined shape. Next, an SiO_x layer 17 is formed to have a thickness of 350 nm by a plasma CVD method, and an a-Si film (not shown in figures) and an SiN_x layer 18 are formed to have a thickness of 50 nm and 200 nm respectively by a plasma CVD method. Thereafter, the SiN_x layer is etched by a hydrofluoric acid-based etchant to form a channel protective layer of the TFT (not shown in figures). An n^+ a-Si film (not shown in figures) of 50 nm thick is formed by a plasma CVD method to realize ohmic contact. Further, each of the n^+ a-Si film, the a-Si film, and the SiN_x layer 18 is etched to have a predetermined shape by CDE.

[0021]

Cr and Al are laminated by a sputtering method each to have a film thickness of 50 nm and 500 nm to be deposited. Then, Cr and Al are each etched as patterning by a mixture of nitric acid, phosphoric acid, and acetic acid and a ceric ammonium nitrate solution to form the signal line 12 of 8 μm width, a source electrode 13S, and a drain electrode 13D. The n^+ a-Si film exposed between the source electrode 13S and the drain electrode 13D is etched to be removed by CDE using the source electrode 13S and the drain electrode 13D as masks. Furthermore, a transparent conductive film such as ITO (indium tin oxide) is formed to have a film thickness of 100 nm by a sputtering method, and patterned. Thereafter, the transparent conductive film is etched by an aqua regia-based etchant to form the pixel electrode 5[sic] in a rectangular whose size is 65 μm × 65 μm, and an SiN_x film of 200 nm thick as a passivation film (not shown in figures) is formed. Furthermore, a polyimide thin film of 100 nm thick for an alignment film is formed, and then a rubbing process is performed on the surface of this alignment film 19.

[0022]

As a result, the peripherally of the side 14a of the pixel electrode 14 is disposed so as to overlap with the upper surface of the transverse electric field generating electrode 15 where the insulating films 17 and 18 are interposed therebetween. A bossy ridge 16b due to a thickness of the Cs line 16 is formed in a central area dividing the pixel electrode into two portions. An interface between the reverse tilt region B and the normal tilt region A is formed easily due to this ridge 16, and a pixel electrode region between the ridge and the transverse electric field generating electrode becomes a reverse tilt region different from the tilt direction of the alignment film 19 (region A) when a transverse electric field is

generated.

[0023]

On the other hand, the upper substrate 20 is formed of an insulating transparent material such as glass, and a meal film such as Cr becoming the black matrix 21 is formed to have a thickness of 300 nm by sputtering and then is patterned to have a grid shape by photolithography. A 100 nm thick transparent conductive film is formed by a sputtering method to be a common electrode 22. Further, after forming a 100 nm thick polyimide thin film, a rubbing process is performed on the surface of the alignment film 23.

[0024]

Thereafter, an epoxy-based adhesive is printed as an adhesive along a circumference of the alignment film 19 formed over the array substrate 10. Note that the adhesive is not printed in an inlet (not shown in figures). Next, microspheres having a grain size of 5 μm (Micro Perl (product name) produced by Fine Chemicals Division, Sekisui Chemical Co. Ltd.) as a gap material (not shown in figures) is dispersed on the surface of the array substrate. Subsequently, after the upper and lower substrates are disposed so that the alignment film 19 are faced to the alignment film 23 and the rubbing directions are set to be different from each other by 90°, the both substrates 10 and 20 are attached by heating to cure the adhesive.

[0025]

Next, ZLI-1565 (produced by E. Merk & Co. Inc.) added with S811 (produced by E. Merk & Co. Inc.) of 0.1 wt% as a liquid crystal material is injected from the inlet to form a 5 μm thick liquid crystal layer 30 by a general method. Subsequently, the inlet is sealed with a ultraviolet curable resin.

[0026]

Thereafter, polarization plates are further attached to the upper and lower substrates; thus, an active matrix liquid crystal display device is completed.

[0027]

A viewing angle dependence of a liquid crystal display device thus manufactured according to the present invention is examined, and a preferable result shown in FIG. 3 is obtained. In other words, FIG. 3 shows a contrast ratio when an angle inclining to the viewing direction on the basis of the substrate vertical direction is set to be a viewing angle θ, and it is assured that an almost symmetrical contrast ratio can be obtained in both upper and lower directions.

[0028]

(Embodiment 2)

FIG. 4 shows a liquid crystal display device according to the present invention, and

same portions are denoted by the same reference numerals in FIG. 2. As shown in the figure, a transverse electric field generating electrode 15 is formed between a scanning line 11 and a pixel electrode 14 over a lower array substrate 10. The transverse electric field generating electrode 15 is formed over an SiO_x layer 27 and an SiN_x layer 28 becoming insulating films between the transverse electric field generating electrode 15 and a signal line 12, and it is also disposed over an outer periphery 14a of the pixel electrode 14.

[0029]

The SiO_x layer 27, the SiN_x layer 28, and the transverse electric field generating electrode 15 are formed in the following processes. The SiO_x layer 27 is formed to have a film thickness of 350 nm by a plasma CVD method, the SiN_x layer 28 is formed to have a film thickness of 200 nm by a plasma CVD method, and then the SiO_x layer 27 and the SiN_x layer 28 each are etched to have a predetermined shape by CDE. Further, Cr and Al are laminated by a sputtering method each to have a film thickness of 50 nm and 500 nm to be deposited, and they are etched as patterning by a mixture of nitric acid, phosphoric acid, and acetic acid and a ceric ammonium nitrate solution to form the transverse electric field generating electrode 15.

[0030]

In this manner, the transverse electric field generating electrode 15 is formed upper than a side portion 14a of the pixel electrode; thus, components of a transverse electric field parallel to the substrate can be easily imparted to an electric field formed between a region of the pixel electrode 14 and an electrode 22 of an opposite substrate. Consequently, a reverse tilt region B can be formed with a small electric field.

[0031]

(Embodiment 3)

Hereinafter, Embodiment 3 is described.

[0032]

FIG. 5 shows an embodiment of a liquid crystal display device according to this embodiment. Same portions are denoted by the same reference numerals in FIG. 2.

[0033]

A pixel electrode 14 is formed to be interposed by scanning lines 11, and a transverse electric field generating electrode 15 is formed between the scanning line 11 and the pixel electrode 14 over an array substrate 10 as shown in the figure. On the other hand, a black matrix 21 and a common electrode 22 are formed over an opposite substrate 20. Note that the position of the common electrode 22 corresponding to the transverse electric field generating electrode 15 is shown as a cut-out portion 22a. By removing the common electrode over the transverse electric field generating electrode 15 in this manner, a strong

transverse electric field can be obtained.

[0034]

Further, the position of the common electrode 22 corresponding to a Cs line 16 is shown as a cut-out portion 22b in this embodiment. By removing the common electrode over the Cs line 16 in this manner, a reverse tilt region B can be formed stably.

[0035]

Any alignment film can be used in the present invention; however, it is preferable to use one whose pretilt angle is small, preferably 1° or less. When the pretilt angle is 1° or less, a tilt reverse region can be expanded even if the low voltage is applied to the transverse electric field generating electrode.

[0036]

In the case where one pixel is small, for example, a liquid crystal display device for a projector, a required size of the tilt reverse region becomes smaller; thus, a preferable viewing angle can be obtained even if the low voltage is applied to the transverse electric field generating electrode.

[0037]

In addition, the transverse electric field generating electrode according to the present invention is formed in the neighborhood of the rubbing approaching direction of the pixel electrode, and the shape, the material, or the like may be decided appropriately so that the tilt reverse region is formed in a predetermined area.

[0038]

The area of the tilt reverse region according to the present invention is decided depending on how a viewing angle is set. The ratio of the normal tilt region and the tilt reverse region is not limited to that of 1:1.

[0039]

[Effect of the invention]

According to the present invention, a liquid crystal display device having satisfactory display characteristics of a wide viewing angle and a high contrast, in which the contrast ratio is neither varied nor lowered regardless of the long time display, can be obtained.

[Brief Description of Drawings]

[FIG. 1] a schematic plan view of a substrate in an embodiment according to the present invention.

[FIG. 2] a schematic cross-sectional view taken along line I-I of FIG. 1.

[FIG. 3] a graph showing a characteristic of a viewing angle θ and a contrast ratio in an embodiment according to the present invention.

[FIG. 4] a schematic cross-sectional view of a substrate in the other embodiment according to the present invention.

* [FIG. 5] a schematic cross-sectional view of a substrate in the other embodiment according to the present invention.

[FIG. 6] a graph showing a characteristic of a viewing angle θ and a contrast ratio in a conventional liquid crystal display device.

[Description of the References Symbols]

10 array substrate

11 scanning line

12 signal line

13 TFT

14 pixel electrode

15 transverse electric field generating electrode

16 auxiliary capacitor line (Cs line)

20 opposite substrate

30 liquid crystal layer

A normal tilt region

B reverse tilt region

D disclination line

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[Amendment]

[Date submitted] October 6, 1999

[Amendment 1]

[Document Amended] Specification

[Item Amended] Scope of Claim

[Method of Amendment] Modification

[Contents of Amendment]

[Scope of Claim]

[Claim 1]

A liquid crystal display device comprising:

an array substrate having a plurality of scanning lines and a plurality of signal lines each arranged in a column and a row, an active element arranged in a matrix and controlled by the scanning line and the signal line, a pixel electrode connected to the active element, and an alignment film formed to cover the pixel electrode;

an opposite substrate having a common electrode disposed to face to the pixel electrode and an alignment film formed over the common electrode; and

a liquid crystal layer disposed between the array substrate and the opposite substrate, and in which liquid crystal molecules are pretilted in a predetermined angle and direction by the alignment films,

wherein an transverse electric field generating electrode is formed to control liquid crystal molecules corresponding to a part of a region in the pixel electrode so that the liquid crystal molecules corresponding to a part of a region in the pixel electrode have different standing up direction or standing down direction from liquid crystal molecules in a region other than the part of a region.

[Amendment 2]

[Document Amended] Specification

[Item Amended] 0001

[Method of Amendment] Modification

[Contents of Amendment]

[0001]

[Industrial Field of the Invention]

This invention relates to a liquid crystal display device.

[Amendment 3]

[Document Amended] Specification

[Item Amended] 0011

[Method of Amendment] Deletion